PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO HEAT EXCHANGERS

(71) We, COVRAD LIMITED, a British Company, of Sir Henry Parkes Road, Canley, Coventry, CV5 6BN, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be described in and by the following statement:—

The present invention relates to an adhesively-bonded heat exchanger and particularly but not exclusively to an adhesively-bonded radiator. The heat exchanger may be made of aluminium (the term "aluminium" including alloys of aluminium) or, for example, of ferrous, or copper alloys.

Radiators are known which can be assembled from a plurality of elements each of which consists of a heat transfer fin section with half-tubes bonded to either side thereof, two half-tubes together defining a liquid passageway. A fuller description of such radiator construction may be obtained from U.K. Patent Specification No. 1,242,397.

In order to improve the thermal efficiency of the radiator, attempts have been made to reduce the thickness of the adhesive layer used for bonding the fins to the half-tubes. It has hitherto been found necessary however to use a layer of adhesive having a thickness of several thousandths of an inch, typically about 0.002 inches, in order to provide sufficient peel strength to allow for flexing of the radiator during use.

According to the broadest aspect of the present invention there is provided an adhesively-bonded heat exchanger comprising a heat transfer assembly including fins having tubes bonded to either side thereof, in which at least part of the adhesive for bonding the fins to the tubes is contained in grooves formed in the tubes.

Preferably the tubes are of flattened transverse cross-section and the grooves are located adjacent each longitudinal side edge of the tubes.

The portion of the fins and the tubes between the grooves may be placed in intimate contact with each other, or alternatively a thin layer of adhesive may be used to bond the portions together.

The tubes may be formed as half-tubes, the half-tubes being bonded to opposite sides of a fin and the half-tubes being connected to other half-tubes to form whole tubes, which, in the case of a radiator, pass liquid coolant.

Alternatively the tubes may be formed as whole tubes, for example by extrusion, the tubes being bonded to opposite sides of a fin.

The invention will now be further described by way of example with reference to the accompanying drawings in which:—

Figure 1 is a diagrammatic illustration of an assembly embodying the invention and not to scale,

Figure 2 is a cross section on the line 2—2 in Figure 1,

Figures 3, 4 and 5 are scrap views showing alternative forms of assembly, and

Figure 6 is a side elevation of an assembled heat exchanger.

Referring to Figures 1 and 2 part of one example of an assembly of fins and tubes is shown. In this example sets of fins 14 are each sandwiched between a male half-tube 10 and a female half-tube 12, and adjacent male and female half-tubes are secured together by turned-over flanges 15 on half-tubes 12 embracing end flanges 17 of half-tubes 10, to form a tube 16, for passing, for example, coolant through the heat exchanger. As shown in Figure 1 two sets of fins 14 have been secured together by a male and a female half-tube bonded to the respective sets of the fins, and male and female half-tubes 10, 12 respectively have been bonded to the opposite sides (upper and lower as shown) of the respective fins 14 for assembly to further sets of fins and half-tubes (not shown) to make up a heat exchanger.

The fins 14, as more fully described in

British Patent No. 1,242,397, are in the form of corrugated strips of metal foil which define louvred heat-transfer secondary surfaces 25 extending generally transversely of the base regions 27. The secondary surfaces 25 on either side of a base region 27 are convergent to afford a closed or substantially closed triangular form. The tubes 16 are formed with longitudinal grooves or channels 18 adjacent each side edge thereof, the remaining portion of the tubes being substantially planar and lying parallel to base regions 27 of the corrugated fins 14.

A thin layer 11 of a first adhesive which may be for example 0.001 inches thick is applied to the planar portion of the tubes 16 and also to the base regions 27 of the respective fin strips 14. This adhesive is a hot melt adhesive which is subsequently allowed to solidify. A bead 13 of a second adhesive, preferably a polyvinylchloride-based adhesive, is applied to the grooves 18 in the tubes, and the appropriate number of units (each including a set of fins 14 and half-tubes 10, 12) are assembled to form a heat-exchanger matrix, in which the beads 13 of the second adhesive have a typical thickness of 0.010 inches. The second adhesive is then partially cured, typically at a temperature of 180° for one minute.

Figures 3, 4 and 5 show various alternative forms which the tubes 16 can take and in one form shown in Figure 3, one half-tube 10A has a longer flange 15 at one end and a shorter flange 17 at the other end, to be secured to a similar, oppositely-facing half-tube 12A, so that the longer flange 15 at each side of the tube 16 is turned over to embrace the shorter flange 17, thus forming the closed tube. In another alternative, shown in Figure 4, instead of half-tubes 10, 12, the tube 16 is made of closed cross-section 22 by any known or convenient process, for example by extrusion. In yet another alternative, as seen in Figure 5, similar end flanges 23 are in abutment and secured together either by adhesive, or by welding or brazing, without having to turn over any flanges of the half-tubes 10B, 12B.

Referring to Figure 6 a completed heat exchanger suitable for use as a vehicle radiator is shown diagrammatically (the fins and tubes being exaggerated for clarity). The heat exchanger is assembled with the fins 14 bonded to and occupying the spaces between coolant tubes 16, as described with respect to Figures 1 to 5, the fins 14 being seen in cross section in Figure 2. The tubes 16 interconnect manifolds 20 and 22 and end plates 24 and 26 are fixed to the ends of the manifolds 20 and 22 to impart rigidity. The manifold 20 is formed with an inlet 28 and the manifold 22 is formed with an outlet 30 to enable coolant to be circulated from the vehicle engine. The manifold 20 is also fitted with an upwardly-extending pipe 32 on the end of which is a filler cap 34. After assembly of the manifolds etc to the matrix, the heat exchanger is heated, typically to a temperature of about 170°C for forty-five minutes, to cure fully the second adhesives 13 and any other adhesive (apart from the first adhesive 11 which does not need to be cured) used during assembly of the heat exchanger.

Thereafter, the heat exchanger is pressurised internally by admitting gas to the tubes 16 and the manifolds 20 and 22 to bring the planar surfaces of the tubes 16 and the base regions 27 of the fins 14 together. At the same time the temperature is raised to about 150°C, which remelts the first adhesive 11, and thus ensures that the contact surfaces of the fins 14 and tubes 16 remain together. The heat exchanger is then cooled prior to releasing the internal pressure, so that the hot melt adhesive 11 re-solidifies, hence bonding the contact surfaces of the fins and tubes together.

It has been found that the first adhesive 11 may be dispensed with, since under normal operating conditions internal pressure within the heat exchanger tubes 16 brings the tubes 16 and fins 14 into sufficiently intimate contact to ensure a reasonable degree of heat transfer therebetween.

Whilst the first adhesive 11 has been described as applied to both the tubes 16 and the fins 14, it need only be applied either to the tubes or the fins.

It has been found that whilst a hot melt adhesive gives satisfactory performance as the first adhesive, other forms of adhesive may be used such as themo-setting adhesives, for example, epoxy resin adhesives; the latter will of course only be cured when the surfaces of fins 14 and tubes 16 have been brought into intimate contact.

The invention enables the separation of the contact surfaces of the fins and tubes to be reduced to zero, where no first adhesive is used, and to less than 0.001 inches, for example 0.0005 inches where a first adhesive is used. In each case heat transfer across the contact surfaces is considerably increased compared with prior methods of assembly.

Conveniently the tubes 10, 12 and the fins 14 are formed of aluminium alloy foil.

WHAT WE CLAIM IS:—

1. An adhesively-bonded heat exchanger comprising a heat transfer assembly including fins having tubes bonded to either side thereof, in which at least part of the adhesive for bonding the fins to the tubes is contained in grooves formed in the tubes.

2. A heat exchanger according to Claim 1

wherein the tubes are of flattened transverse cross-section and the grooves are located adjacent each longitudinal edge of the tubes.

3. A heat exchanger according to Claim 1 or 2 wherein the portions of the fins and the tubes between the grooves are placed in intimate contact with each other.

4. A heat exchanger according to Claim 1 or 2 wherein a thin layer of adhesive is used to bond the portions of the fins and the tubes between the grooves.

5. A heat exchanger according to any one of preceding claims wherein the tubes are formed as half-tubes, being bonded to opposite sides of a fin and the half-tubes being connected to other half-tubes to form whole tubes.

6. A heat exchanger according to Claim 5 wherein the half-tubes are secured together to form whole tubes by a flange on one tube turned over to engage a flange on the other tube.

7. A heat exchanger according to any one of Claims 1 to 4 wherein the tubes are formed as whole tubes, the tubes being bonded to opposite sides of a fin.

8. A heat exchanger as claimed in Claim 5 wherein the half-tubes have end flanges in abutment and secured together by adhesive, welding, or brazing.

9. A heat exchanger according to any one of the preceding claims wherein the fins are in the form of corrugated strips of metal foil, and the corrugated strips comprise two spaced apart sets of longitudinal base regions, a pair of transverse secondary surfaces extending from each of two opposite edges of a base region and being convergent to afford a closed or substantially closed triangular form.

10. a heat exchanger according to any one of the previous claims wherein the tubes are arranged to contain pressurised coolang fluid in use.

11. An adhesively-bonded heat exchanger constructed substantially as described with reference to Figure 1 of the accompanying drawings.

12. An adhesively-bonded heat exchanger constructed substantially as described with reference to Figure 3 of the accompanying drawings.

13. An adhesively-bonded heat exchanger constructed substantially as described with reference to Figure 4 of the accompanying drawings.

14. An adhesively-bonded heat exchanger constructed substantially as described with reference to Figure 5 of the accompanying drawings.

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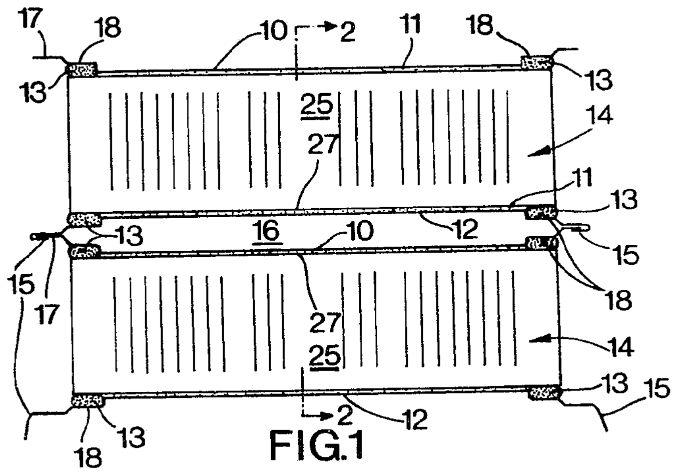
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FIG.1

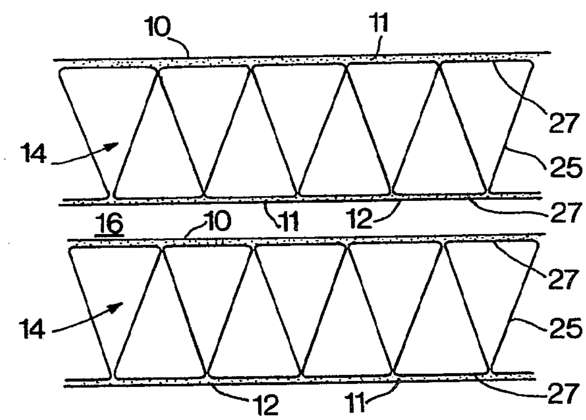
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FIG.2

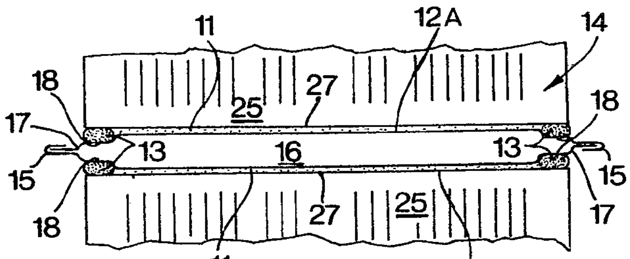

FIG.3

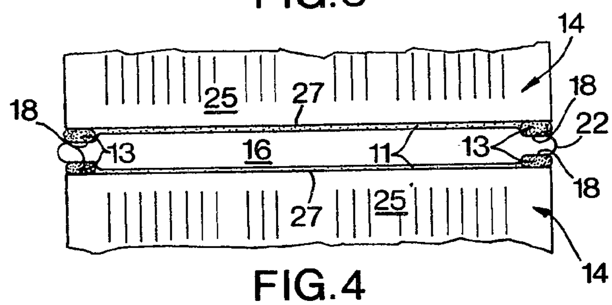

FIG.4

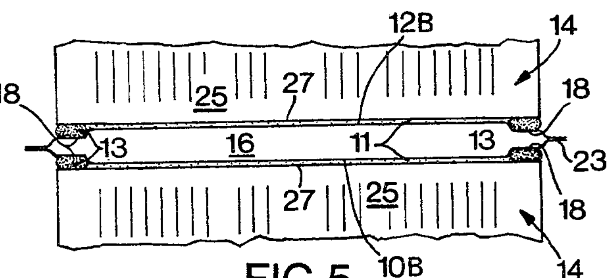

FIG.5

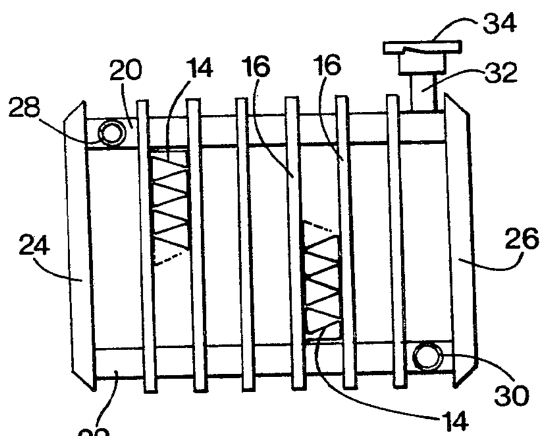

FIG.6